NOTES

on the Symptoms attending the Induction and Maintenance of Chloroform Anaesthesia.

Archibald G. Hay, M.A., M.B.

In the following pages I purpose recording the impressions left on my mind during about twelve months experience of the administration of chloroform, as to the phenomena occurring during the induction and maintenance of chloroform anaesthesia, and their value as guides to the anaesthetist in the administration of the anaesthetic.

As my intention is to regard the subject entirely from the point of view of my own experience, and from the point of view of the practical value of the various phenomena, I shall endeavour to avoid as far as possible the introduction of theoretical considerations. For the same reason, I intend to omit all reference to the writings of the various authorities on the subject.

Since it will be necessary to describe the phenomena as they appear in the various stages of anaesthesia, I shall first of all describe as

shortly as possible the stages of chloroform anaesthesia.

For practical purposes the process of anaesthetisation may most conveniently be divided into three stages.

The first stage is that which intervenes between the commencement of the administration and the supervention of anaesthesia.

The second is the stage of surgical anaesthesia, and extends from the supervention of anaesthesia to the point at which the boundary line of safety has been reached, and the patient begins to be in danger of suffering from an overdose of chloroform.

The third stage is that in which, the administration of the anaesthetic having been pushed beyond the limit of safety, the patient is in danger of death from chloroform poisoning.

The first stage may be subdivided into two periods; the first, associated with coughing,

swallowing, and sensory disturbances, and the second, associated with muscular excitement and struggling. This subdivision, however, is of very little practical value; in part because it is unnecessary, as no surgical operation should be attempted until anaesthesia has reached the second stage; in part because the phenomena of these two periods depend to a great degree on the manner in which the anaesthetic is administered; in part because the sequence of these phenomena is most inconstant: thus some patients, after the first feeling of suffocation, consequent on the inhalation of the gas, pass quietly and rapidly into the second stage; others, after the first few inhalations, enter on a stage of uncontrollable muscular excitement, which either ceases gradually from exhaustion or is cut short abruptly by the sudden supervention of the second stage; while others again, after a period of excitement has passed off, lapse into a state of semi-unconsciousness, which

may last for some time before they pass into the stage of surgical anaesthesia.

The limits of the second stage, or safety zone, as it has been termed, vary very much in different subjects. Thus, while in one case, anaesthesia having been once induced, it is a matter of the greatest ease to keep the patient thoroughly and safely anaesthetised, in another the maintenance of anaesthesia partakes more of the nature of a tight-rope performance, the patient constantly tending to pass from the first stage directly to the third, and back again, without the intervention of a second stage of any appreciable duration.

Having introduced the subject by these remarks on the stages of anaesthesia, I shall now proceed to discuss the phenomena arising during these stages and their value as symptoms.

The symptoms usually mentioned as affording reliable information to the anaesthetist as to the patient's condition are - the conjunctival reflex,

the behaviour of the pupil, the character of the respiration, and that of the pulse. In addition to these symptoms, however, are others, which, trivial as they may seem in themselves, yet, when taken together, are often found to give more reliable information than those enumerated above, which I may call the classical symptoms, and the classical symptoms themselves, or at least some of them, are worthy of much more detailed study than is generally accorded them.

Thus the conjunctival reflex affords valuable information as to the patient's condition, when one realises that there are really two conjunctival reflexes, which may be called the superficial and the deep. The superficial reflex is the one usually adopted as the guide to the condition of the patient, with most unsatisfactory results. It is sought by raising the upper eyelid and lightly touching the conjunctiva over the sclerotic or cornea (the latter giving a more delicate result),

and watching for an attempt to wink the eye. This reflex is liable to be abolished very early by the local anaesthetic effect of the chloroform vapour, so that, while its presence is proof that the patient is still in the first stage, its negative value as an indication of unconsciousness is absolutely nil. The deep conjunctival reflex is sought by raising the eyelid, placing the tip of a finger with a certain degree of firmness over the cornea, and keeping it in contact with the eyeball for an appreciable space of time, and watching for a movement of the eyelids. The most delicate indication of the attempt to close the eye is obtained by watching the lower eyelid, which may be seen, when the patient is almost but not completely anaesthetised, to be drawn slightly towards the inner canthus, while at the same time its free border loses its *f*- shaped contour and becomes a straight line. One should never seek to entirely abolish this reflex, as its entire disappearance indicates

that the patient is approaching dangerously near to the third stage of anaesthesia. This deep conjunctival reflex, though an extremely reliable test at first, tends to disappear as anaesthetisation is prolonged beyond a period of about, on an average thirty or forty minutes, and in three or four cases out of between two and three hundred I have found it disappear very much earlier.

In examining for the conjunctival reflex, if one eye fail to respond, the other should be tried, as it is frequently the case that an eye which has already undergone frequent examination becomes affected directly by the chloroform vapour, while the other is still sensitive. In testing this reflex it is well also to see that there is no mechanical impediment to the movement of the eyelids. I was considerably puzzled in one case in which, the right eye, which had been frequently examined, failing to respond, I tried the left, with the same result. As it was evident, from the character

of the breathing, and from other signs, that the patient was not completely under the influence of the anaesthetic, I looked for an explanation, and found that, as I was holding the jaw forward with the fingers of the left hand, the ball of my thumb was resting on the malar bone and so anchoring the tissues that the lower eyelid was prevented from moving inwards in response to the touch on the eyeball. On removing my hand, the reflex was at once obtained.

Besides the conjunctival reflexes, the eye affords other indications of the patient's condition. When the patient is not yet thoroughly "under," if the upper eyelid be raised the lower lid will often be seen following up the other, as though seeking to supply its place as a shield to the eyeball. In cases in which the patient is more deeply anaesthetised but not quite beyond the first stage, though the lower lid does not move when the upper is raised, its free border is seen

stretching across from inner to outer canthus in a straight line, instead of showing its usual curve.

These are trifling indications, but they are valuable in that they do away with the necessity for frequently touching the conjunctiva, and so lessen the subsequent discomfort of the patient, and also, by shortening the time necessary for examining the eye, cause it to be less speedily affected by the local action of the anaesthetic.

The eyeball, by its tension, as appreciated by the finger, affords another very valuable sign, and if need be, danger-signal. Three degrees of tension are appreciable. There is first the firm, elastic, almost aggressive tenseness of the eyeball of the first stage, which is the same as the tenseness of the eyeball of the conscious man. This gradually merges into the relaxation of the second degree, which corresponds very closely with the transition from the first to the second stage of chloroform anaesthesia. As the anaesthetic

condition tends to pass beyond the limits of the safety zone the eyeball becomes still more lax, this second relaxation usually preceding the dilatation of the pupil as the second stage passes into the third, until in some cases it becomes almost as flaccid as the eyeball of the recent cadaver. When this degree of relaxation has been reached the pupil has begun to dilate, the face is pale, the pulse feeble, and the breathing shallow, and syncope is evidently very near at hand. It is needless to say that this stage should never be reached, and that any relaxation of the eyeball beyond the second degree should be the signal for instant withdrawal of the mask, even though the pupil remain contracted and there be no other symptom of over anaesthesia. The transition from the first to the second degree of relaxation is usually an extremely gradual one, coinciding very closely with the passage of the patient from the first to the second stage of anaesthesia, while the

passage from the second degree to the third is, like the dilatation of the pupil under an overdose of chloroform, frequently very abrupt.

That the relaxation of the tension of the eyeball is not, as has been suggested, due to changes in the circulation, but really to relaxation of the ciliary muscle, is shown, I think, by the following facts.

During the circulatory depression which precedes vomiting, the eyeball does not as a rule become relaxed, but rather more tense. Exceptions to this rule are occasionally found amongst debilitated, strumous children, in some of whom, while vomiting while recovering consciousness, I have noted a slight, relaxation of the eyeball during the act of retching, passing away in a very short space of time, and giving place almost immediately to the tenseness of the first degree.

On examining and comparing the two eyeballs it will occasionally be found that one is more lax

than the other, the local action of the chloroform vapour having presumably affected one ciliary muscle more than the other, for it is scarcely likely that the local action of the chloroform vapour would appreciably affect the blood supply of the one eye more than of the other.

In the intense circulatory depression which sometimes accompanies such operations as castration, when the pulse flags, the patient becomes pale, and breaks out in a profuse cold sweat, the eyeball has not, in cases which I have observed, relaxed from the second degree, in which it has continued throughout the operation, both before and after the cord had been interfered with.

Finally, in cases in which, apparently as the result of the return of reflex action, due to inefficient anaesthetisation, the pulse has flagged and the patient become pale, the eyeball has instead of relaxing become more tense, and as the symptoms of circulatory depression passed off under

the influence of more chloroform, it has again relaxed.

With regard to the pupil, the general rule holds good in almost all cases, that during the first stage of chloroform anaesthesia the pupil is variable in size, that in the second stage it is contracted, moderately or firmly as the case may be, and that in the third stage it becomes dilated. As an indication of the patient's condition I have found the pupil most reliable in healthy adult males. In delicate women, and still more in scrofulous, weakly children, the pupil may be quite unreliable as a test, and in some such cases I have found that so long as the patient was fully anaesthetised the pupil remained widely dilated, contracting only when the patient showed signs of "coming out." In some patients, also, usually women and children, the value of the pupil as a danger signal may be diminished by the fact that the dilatation of the pupil may coincide with or even follow, instead of

preceding, the occurrence of vomiting or syncope.

Even when the pupil reacts normally it is sometimes difficult to tell whether its sudden dilatation indicates that the patient has had to much or too little chloroform. As a rule, by removing the mask from the patient's face and watching whether the pupil continues to dilate or begins to recontract, we can very soon tell whether he has had too little or too much, but the tension of the eyeball affords us a more rapid test. If with a dilating pupil we find the moderately relaxed eyeball become more tense we may be almost absolutely certain that the patient is "coming out," while if on the other hand, we find that the eyeball has become still more relaxed, we know that the administration of the anaesthetic must be at once suspended, and the patient very carefully watched, as he is probably on the verge of syncope.

The pupil as a rule continues to react to light all through the second stage, ceasing to do

so only when the third stage, is coming dangerously near, so that the reaction to light is not to be recommended as a safe guide.

In some patients the muscles of the orbit continue to contract for a considerable time after the patient is to all appearance fully anaesthetised, so that as a general rule movement of the eyeballs ought not to be taken to be by itself a proof that the patient is not fully under the influence of the anaesthetic. When the eyes are at rest their axes are usually in the horizontal plane with reference to the usual position of the body. With regard to the presence of strabismus, I have no figures to go by, but believe that, in the majority of cases, the axes of the eyes are parallel, although I have noted many cases of convergent strabismus, and since my attention was directed to the matter, two months ago, I have observed four cases of marked divergent strabismus, in children being operated on in the Dispensary of the Royal Hospital for Sick Children,

Glasgow.

The respiration affords valuable indications for the differentiation of the various stages of anaesthesia. During the first stage, after the preliminary disturbances due to the irritating effect of the vapour, and to fear or excitement, have passed off, it is usually somewhat rapid, with deep inspiration and forcible expiration, the latter frequently possessing a vocal character. As narcosis increases the rate frequently becomes accelerated to a marked degree, and at the same time the inspirations become proportionately shallower, while the expiratory impulse becomes stronger. As anaesthesia becomes more complete this acceleration is lost, the rate falling to about the normal standard, while inspiration becomes deeper, and expiration seems to cease entirely to be the effect of muscular contraction and is apparently due solely to the elastic recoil of the lungs and chest wall, aided by the falling back of the

abdominal viscera, displaced by the diaphragm as it descended in inspiration, for at this stage the breathing is usually markedly abdominal in character. These phenomena combine to give the respiration a noticeably automatic character, which is distinctive of the second stage of chloroform anaesthesia. If the administration of the anaesthetic be pushed further, this regular, deep, automatic character of the respiration is lost; the breathing becomes rapid, often irregular, shallow, and sighing, with a distinct expiratory impulse.

The stertorous breathing which the earlier chloroformists sought to obtain, when it occurs, marks a stage intermediate between the two last mentioned, and indicates as a rule that the administration of the anaesthetic has been pushed further than is required, though not necessarily to a dangerous extent.

If,while the breathing is of the automatic type spoken of, instead of being pushed the administration

be suspended sufficiently to allow the patient to begin to "come out," the character of the respiration undergoes another change. Inspiration is shortened and occasionally somewhat halting, and the pause between it and the succeeding expiration almost disappears, while expiration is prolonged and somewhat forced, and followed by a lengthened pause, the result being to give to the respiration a curiously volitional character. When once the patient has been thoroughly anaesthetised, these changes usually precede by a distinct interval the indications given by the pupil, and, though by a shorter interval, those to be gained by examining the tension of the eyeball, and their value is less liable to be impaired by prolonged anaesthetisation. The depth or shallowness of the breathing may be readily estimated by placing a hand or cheek over the patient's mouth and nostrils and noting the increase in temperature of the expired air, regard being paid at the same time, of course, to the

rapidity of the breathing, and the duration of the pause between inspiration and expiration.

The character of the respiration varies very much in different individuals, and also according to the nature of the operation. The largyneal element in the breathing so frequently met with during operations on the genitals, perineum, and rectum, and about the neck, need only be mentioned in passing, as it is described at some length in most books on the subject of anaesthesia. In one patient, however, I have met with an anomaly in respiration which I have not found recorded by any writer. The patient was a stoutly built, thick-necked man, 28 years of age, strong and healthy, who came to the Western Infirmary to have masses of enlarged glands removed from both sides of his neck. These glands were so numerous, and so obstinately adherent to the surrounding structures, as to require four prolonged operations for their removal. On each occasion the breathing during the first stage was markedly

laryngeal. When the second stage had been reached and, the incision having been made, the glands were being manipulated, respiration, previously quiet and regular, suddenly ceased at the end of an inspiration, the breath being held for from fifteen to twenty seconds, until the face began to assume a dusky hue, and was then quietly resumed, no alteration having meanwhile occurred in the size of the pupil or the tension of the eyeball, both of which signs proved in this case extremely reliable. The pulse remained slow, regular and full, until near the end of the pause, when it began to increase a little in rate, steadying down again, however, after the first few respirations. This phenomenon was repeated several times during each operation, and after the second or third repetition nothing was done in the way of pulling out the tongue, pushing forward the jaw or performing artificial respiration. No lesion of heart or lungs was found, but the man suffered from respiratory obstruction due to

post-nasal adenoids. No immediate connection was made out between the respiratory pause and traction on the pneumogastric nerve, but the pauses occurred only during the handling of the glands, not while the incisions were being made or stitched up. The breathing was not of the Cheyne-Stokes type, but ceased abruptly at the end of an inspiration, and was resumed as suddenly with a sighing expiration.

The character of the pulse, as regards its rate, strength, volume, and regularity, furnishes in many instances a reliable indication as to the patient's condition. In the first stage, in the healthy subject, its rate is usually accelerated, without the appearance of any other change; in debilitated patients its strength and volume may at the same time be somewhat reduced. In the second stage its rate as a rule falls slightly below the normal, and it becomes full and strong. In cases in which during the first stage it has been weak and perhaps irregular

the supervention of anaesthesia is usually followed by marked improvement in its character. When the third stage is reached the depressing influence of the anaesthetic on the circulation is manifested in a diminution in the strength and volume of the pulse, which is usually accelerated, though sometimes slowed, and occasionally irregular.

The value of the pulse as a guide to the anaesthetist is seriously impaired by the fact that when the patient has reached the second stage the administration of too much or of too little chloroform may affect the pulse in the same way. If too much be given, syncope may be induced by the direct action of chloroform on the heart, while, if too little be given the conduction of peripheral sensation being restored, the heart's action may be interfered with reflexly, or vomiting with its attendant tendency to syncope may occur. Sudden flagging of the pulse, therefore, during the administration

of chloroform, may mean that either too much or too little of the anaesthetic has been given. As in either case the pupil tends to dilate and the character of the respiration to change, we are obliged to trust to the ocular tension, and even that may be temporarily diminished just before vomiting occurs. If the mask be withdrawn and the pupil carefully watched, the dilatation may in many cases be observed to continue if too little chloroform has been given, or to cease and give place to recontraction if due to an over dose. The conjunctival reflex is not to be depended on in such cases, as it is very apt to be in abeyance during the period of depression which precedes the attempt to vomit. A slight movement of an extremity, straightening of the lower eyelid, an attempt to swallow, or that heaving of the anterior abdominal wall which is the prelude to vomiting, at once clears up the doubt.

Occasionally, though rarely, the chloroformist meets with a case in which all the usual indications

fail him. From the site of the operation - on perineum, neck, mouth - or the presence of adenoids, the respiration may be disturbed and it occasionally happens also, while anaesthetising a child, that if the patient has "gone under" while crying, respiration continues to be interrupted by sobs throughout the whole subsequent administration of the anaesthetic. The conjunctival reflex may disappear early, ocular tension may become permanently relaxed, the pupil may prove unreliable, while the pulse, alone, is never to be regarded as a safe guide. In such cases the administration of the anaesthetic must be conducted in a more or less hap-hazard way, the patient's condition being estimated by the presence or absence of muscular movements, swallowing, coughing, etc. That is to say, he must be kept as nearly as possible on the boundary line between the first and second stages, which is a dangerous and unsatisfactory condition.

Even in these cases, however, if carefully looked

for, trifling little indications may be noted, which enable the anaesthetist to keep the patient in a fairly satisfactory state of anaesthesia. Thus in the case of a man whose rectum was being examined under chloroform, in whom the usual indications proved unreliable, I observed that two small wrinkles running outwards and downwards from the inner canthus of the right eye became more defined when the chloroform was withheld for a time and tended to disappear when its administration was pushed. By watching these wrinkles it was possible to keep the patient in a satisfactory state of anaesthesia for nearly half an hour. In another case, that of a girl who was undergoing an operation for the removal of tubercular glands from her neck, the nature of the operation led to alterations in the character of the respiration, while the position of the child's head and of the assistant's hands made it extremely difficult to examine the eyes. By watching, however, the position of the patient's right foot as she lay on her back it

became possible to maintain a satisfactory state of anaesthesia for more than an hour. It was noted that as the administration of the anaesthetic was pushed the foot slowly fell outwards until it reached a position of almost complete eversion; if now the administration was suspended the foot gradually recovered its vertical position, and even became slightly inverted. This inversion of the foot was completed before any other muscular movement or other sign of returning consciousness occurred. If chloroform was still withheld the left thumb became flexed into the palm of the hand. The anaesthetic being again administered the thumb relaxed, and the foot slowly fell outwards again. By administering just enough chloroform to keep the foot everted a sufficient degree of anaesthesia was maintained throughout the operation.

Though it is possible to keep such patients so thoroughly anaesthetised that the operator is unaware of the existence of any difficulty in the matter, yet

to the anaesthetist such cases are always unsatisfactory, inasmuch as he is compelled, in the absence of the usual danger signals, to keep the patient hovering on the border line between the first and second stages, since his only indication for administering or withholding the anaesthetic is the presence or absence of symptoms of the return of reflex action, an occurrence which it is most desirable to avoid if possible.

In concluding these remarks I would emphasise the statement that it is quite impossible to administer chloroform according to any routine system. Each case must be carefully studied from the very commencement of the administration of the anaesthetic, in order to ascertain as early as possible which symptoms furnish the most reliable indications as to the condition of the particular patient who is being anaesthetised. No two patients behave exactly alike under chloroform, and in no two patients are the relative values of the various symptoms the same. In one the

behaviour of the pupil is alone sufficient to guide us in the administration, in another the ocular tension, in another the conjunctival reflex, in another the character of the respiration, furnish us with the most reliable information, but in the majority of cases no single symptom is reliable in itself, but must be taken in correlation with one or more of the others.

Moreover, the relative values of the various symptoms in the same patient frequently undergo a change as anaesthetisation is continued. Thus during say the first half hour of an operation the deep conjunctival reflex may be sufficient to furnish all the information necessary, the other symptoms being used merely to check its indications, then when it fails the state of the pupil becomes our guide. After a time this also may cease to be reliable, and we fall back on the ocular tension. In a prolonged operation this also may yield to the effect of the chloroform vapour, and we are left with only the

character of the respiration and the pulse to guide us. If, also, during an operation the patient be allowed to "come out," so that vomiting is threatened or actually occurs, it occasionally happens that the pupil fails to regain the stable character proper to the second stage of anaesthesia, but remains variable in size and unreliable; the conjunctival reflex may altogether disappear, the eyeball may become relaxed, and the pulse rapid and feeble, while the respiration persistently refuses to reassume the automatic rhythm which it previously possessed, even although, in the attempt to secure the reappearance of the phenomena which characterise the safety zone, the anaesthetic be pushed until unmistakeable symptoms of over administration manifest themselves. In such cases the systematic study of the trivial symptoms from the beginning of the administration comes to be of the greatest possible value to the anaesthetist.